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COURSE IN NATURE STUDY*

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with an Introduction
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I. Introduction

The question is seldom asked nowadays whether or not the study of nature shall be made a part of the elementary curriculum. The growth of opinion during the past few years has answered the question in the affirmative. The general acceptance by educational authorities of the arguments and views of those who have studied the question has brought the educational world face to face with the problem of handling a subject newly added to what appears to be an overcrowded curriculum.

It will be fitting here to call attention to the main arguments which have brought about this result.

It has been held since the time of Horace Mann that the inductive method of study should be used in our elementary schools. This method calls for recognition of the value of facts, and for training in the various methods of observation and in generalization. Work of this kind cultivates that scientific attitude of mind which is more and more the need of modern civilization. The obvious way to reach this end is through the use of the materials of nature at first hand by means of the laboratory method. And, in point of fact, the laboratory method is valuable just in

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proportion as it attains these results. It succeeds when it trains the child in inductive reasoning; it fails, at least in elementary education, when it becomes an end in itself.

It has also been argued that an acquaintance with nature reacts upon the individual by deepening and enriching the emotional life. This in turn tends to make people better, purer, and happier. More recently a very important economic bearing has been pointed out as attaching to this effect upon the emotional life. It is said that immigration from rural communities * to the city will be checked when the beauty and interest which attach to country life are fully appreciated. If by the study of nature the farming classes become more intelligent, if they value properly the advantage and beauty of their natural environment and strive to make their home surroundings more attractive, the importance of such results can hardly be overestimated.

It should be pointed out that the interest which the study of nature fosters is both immediate and subsequent. As an example of the effect of immediate interest, may be cited the fact that it reacts favorably upon the whole work of the school. The crowded curriculum is not so burdensome when the nature study illumines in so many ways the rest of the work. The study of nature may impose new tasks, but they are gladly received because of the difference in the method of attack, and the new and refreshing point of view which is gained spurs the student to self-imposed effort. On the other hand the subsequent interest leads into life itself. One aim of formal education is to prepare persons for both the duties and the enjoyments of life. The function of natural science as a factor of that formal education is not merely to train scientists. These form at present, and will always form, only a very small fraction of the people. The chief end of such study is to enable the average person to understand and have a share in that scientific spirit which ought to be the common heritage of all; to have a faith in the results of proper scientific investigation which makes for clean living; and finally to have and to possess an abiding satisfaction in the things of nature which will attract the mind at times away from the strife of modern living to a quiet contemplation. Some intimate knowledge of nature will certainly not diminish one's ability to enjoy it. On the contrary, it insures an intelligent appreciation of the facts of

* Cornell leaflet, *What Is Nature Study?*

nature which must always carry the mind beyond the working limit of mere curiosity.

It has been mentioned above that nature study may be expected to have certain ameliorating effects upon the rural population. It is also to be desired that those whom fortune forces to live in the city shall have a better understanding and appreciation of the work of the farmer. It is worth much to have the ability to get another's point of view. Those studies which help persons to an intelligent sympathy with the workers in other fields of labor broaden the character. In this respect nature study and manual training stand together; they tend to dignify labor and thus improve social conditions.

It is implied in these statements that people will thus be the better prepared for citizenship. The conservation of our natural resources, such as forests and the like, is dependent on an enlightened public opinion. The bettering of the conditions of community life which depends upon scientific methods depends also upon the willingness of the people of the community to do their personal share of the work. It takes the combined appeal to the reason and to the emotions to compass these ends, and it is the high privilege and duty of the teacher to bring this appeal to the young.

In general, then, we conclude that the aim of nature study is to prepare the individual for life by training his mental power of observation and of generalization, by deepening and rationalizing his emotional life, and by increasing his social worth. We have separated these aims for the sake of definiteness and emphasis. It must not be supposed, however, that there is a separation of the corresponding motives in the mind or in the processes of instruction.*

In accordance with these views an attempt has been made to introduce nature study into the Horace Mann School. In seeking, however, for more definite thoughts for guidance in laying out a course of study, it has been necessary to lay down a few principles which are more or less inferential from the general propositions presented above.

One of these is that nature study is, in reality, a study. It is and must be an essential part of the serious business of education in the school. The amelioration of school work must be sought

* See Huxley, *Science and Education*, p. 175.

in changes in the objects and methods of study, rather than in a change from work to dawdling and guessing. It follows that nature study must not be "wholly informal and unsystematic, the same as the objects are which one sees," if by that is meant that there shall be no thoughtful planning for the course of work. On the contrary, the work must be most carefully and systematically laid out, and the plan adhered to. It is to be feared that the promulgation of the doctrine of informality may do much harm in not accentuating the necessity of careful preparation on the part of the teacher.

In the second place nature study does not confine itself to organic nature; inorganic nature is also within its scope. Again, materials drawn from nature must be the basis of the work. This does not, however, mean that other sources, such as books, may not have their contributory value.

There must also be a serious attempt to correlate the nature studies with the other studies of the curriculum so far as this can be done with advantage to all. Exactly how far the idea of correlation can be carried out will more often depend upon the skill of the teacher than upon scheduled instructions.

Moreover, the course of study must be planned to make the most of the inductive method, which proceeds from the known to the unknown. Nature study at the first must find its material in the immediate environment of the child, and as the mental grasp strengthens and the mental horizon broadens, new sources are made available. We believe that this is an important principle, for in this way the home and the school-life can be woven together in the life of the child. In point of method, then, the work in the earlier years must be observational. The thought content must gradually increase as the higher grades are reached.

Finally, the choice of materials must often be determined by the seasons. It is of the utmost importance that the teacher select wisely from what is available; it is of equally great importance that the pupils learn to follow the seasons and find pleasure and profit in what the seasons offer.

The reader must judge for himself whether the principles above cited are correct and whether the outline which follows is in harmony with them. At any rate this course of study is now in

actual operation in the Horace Mann School. No claim is made for it, other than that it represents earnest effort to contribute something to the solution of the problem of nature study.

In reading the outline the following points should be kept in mind: The work from the fourth to the seventh grades is closely associated with the geography. In the fourth grade the subject of general commercial relations is considered with especial reference to the lumbering, hunting, and fishing industries. It is therefore fitting that such topics as the trees, dog, and the like, are chosen. It is hoped that a further correlation with manual training may later be made in connection with the study of the wood of trees. The work of the sixth grade is in physics and stands in direct correlation with the geography in that grade. The course for the fifth grade must be considered as preparatory to the geography in the sixth. In the seventh grade the study of physics is directly correlated with the manual training, while it is at the same time a preparation for the physical science in the High School. Similarly the work of the eighth grade is a preparation for the High School. In this grade a serious attempt has been made to introduce a course embodying the essentials of physiology, meaning thereby not merely the study of the human body but strictly the essentials of both animal and plant physiology. This is done because we believe that such a course is of much more value educationally, bringing out as it should do the essential unity of animal and plant physiology, than the usual course in physiology and hygiene. That idea of physiology which makes it the study for the most part of the two hundred odd bones in the human frame, leads us to believe that it is time to begin on a new tack. It must not be thought, however, that the course is not aiming at the human aspect of the study, for it is of profound importance that students should have accurate information concerning the workings of their own bodies. Furthermore, there could hardly be a better preparation for the work in biology, soon to follow in the High School, than the training given in such a course. *F. E. L.*

II. General Remarks on the Course in Nature Study in the Horace Mann School

In the following outline there has been no attempt to present an ideal course in nature study, but simply one that seems best

suited to the present needs of the elementary grades of the Horace Mann School. An effort has been made to utilize every advantage that our locality affords and to begin with familiar objects near us. We are fortunate in still having some unoccupied space about the city and in being within short distance of several excellent places for field work, beside enjoying privileges in the way of museums and collections that the municipality affords to all schools within its limits.

Although a definite plan has been outlined for each grade, it is certainly not desirable that every detail of arrangement be rigidly adhered to. It may be found necessary in some instances to shift certain topics so that closer correlation may be established among subjects in the same grade. It is believed, however, that there are distinct advantages in having a time set apart on the program for carrying out a very definite plan of nature work throughout the School. The more informal method, by which any material that happens to come to hand is utilized, and odd times during the day chosen for nature lessons, is no doubt rich in results when skillfully used by the trained naturalist whose interest is pre-eminently in the out-of-door world, and whose breadth of view and insight render him capable of bringing forward the most vital facts and relationships. Nevertheless, observation has led us to think that there are certain dangers arising from too great freedom in the use of this method by teachers who have had little scientific training.

In the first place, we believe that there can be no effective teaching of nature study until it is more generally recognized that just as careful preparation is needed for this subject as for history or English. As nature study is comparatively new in the field of elementary education, and involves a knowledge of so many subjects, teachers should be assisted by every possible means for successfully undertaking the work. With the various duties required it is impossible for the majority of grade teachers to find for themselves the most reliable sources of information or to know the most fundamental facts and relations of the various subjects in the field of natural science. It is therefore suggested that a few main units of work be assigned for each grade, thus allowing time for preparation, not only by reading but more especially by the study of material and experimentation, so that questions of doubt or inquiry arising may, as far as possible, be

settled, and skill in manipulation be acquired, before presenting the subject in class. In this way greater confidence and caution, as well as a more intelligent interest, will be brought to bear upon class-room work.

Some of the evils resulting from an indefinite plan and lack of preparation are the constant repetition of work throughout the grades, the careless use of analogies, the drifting away from truth by making statements which sound well but too often merely cover ignorance, and, finally, the slip-shod performance of experiments that with a little previous practice in manipulation of simple apparatus could be made of greatest educational value. One would better confess ignorance and leave experiments undone. There are too many careless workers and superficial thinkers already, to warrant any method of teaching on our part that shall add to their number.

While we would urge a definite plan and good preparation for the bulk of the work, we do not wish to emphasize this to the exclusion of that invaluable spontaneity that comes from the incidental knowledge which teacher and pupils pick up together. It is true here, as elsewhere, that some of the most valuable knowledge that goes to make up the sum of our education has been gained incidentally. If any interest is shown by the teachers, boys and girls will bring all kinds of things to school, and this interest in collecting, unless thoughtless waste of life is shown, should be encouraged, and the specimens cared for if they are of any value. We have also found that pleasant relations may be established between classes if the children give specimens which they have brought to school, to that grade to which such material would be of special value for illustration or study.

Animal and Plant Life.—In glancing over the general outline, it will be seen that the plan does not aim to present either animals or plants in classified order. The interests of the children, and the relation of subjects in a grade, have been the controlling ideas in the selection of types and groups. For example: in the first grade the squirrel and the oak tree are taken together; in the fourth the dog, with hunting centres and forests. What may be termed the natural history aspect of animal life is made prominent throughout the work and, as far as possible, animals are observed not only in the class-room but also in their natural environment.

Birds are studied in the first three grades, taking the large

domestic types in the first and second years, and our familiar wild birds in the third. In every case the living bird is to be studied, but in order that certain prominent details of structure may be more clearly observed a few well-mounted specimens of the common birds with their nests may be introduced in such a way as to do no harm.

Although it is fully recognized that insect life is a subject which has a strong interest for children, it has nevertheless been omitted as an assigned subject in this course of nature study, because it has not seemed clear how we could secure any valuable results from the study except as it is taken in an incidental way. The Horace Mann School closes about the first of June and does not open until late in September. We miss, therefore, the opportunity of studying the abundant insect life in June and September. Furthermore, in every city school field work in this direction has serious limitations and it is often difficult to secure the large insects that are especially valuable for study in class. Since it is the life and habits that we wish to study rather than details of structure, we believe that the most successful work will be that done with the children as specimens come to hand. It is one kind of work which gives opportunity for developing that spontaneous interest previously referred to. Among specimens which boys and girls will probably bring to you are, cocoons, caterpillars, and various larvæ, galls, and egg cases. It is not necessary to know all about everything that is brought in this way, if you are familiar with the sources of information that will help out observation.

Near the end of the course, the study of animal distribution gives an opportunity for a general summary of the animal study of previous grades and for the expansion of knowledge to include types adapted to other conditions of life than those with which we are familiar.

Plant life in the first three grades centres mainly around garden work, of which a detailed statement will be found in the following outlines. In grades above the third, a certain group of plants is taken up for each year, and this work is finally summarized in the seventh grade by the study of local plant societies and plant distribution over large areas.

Special trees are assigned for careful observation in all except the last three grades. It is hoped that this study will give the

ability to recognize our common trees in all seasons and to know them with ever-increasing intimacy.

Physiology.—Incident with the study of animal and plant life and physical science, some of the simple principles of hygiene are introduced throughout the grades, culminating in general physiology as outlined for the eighth grade. This work is distinctly different from the biology given in the High School, where no time is taken for human physiology, and where the morphological treatment is more prominent than the physiological.

Physical Science.—Elementary physical science is definitely planned for from the fifth grade upwards; before that time such facts are introduced only in connection with study of weather, atmosphere, and manufacturing industries. Simple experiments in heat are arranged for the fifth grade, in order that there may be a foundation for some of the principles constantly used in the physical geography of the sixth grade. The geography of this grade gives a review of the subject of heat by a constant application of facts and principles to such phenomena as winds, ocean currents, and the like. In the sixth grade a study of air is introduced and directly applied to the study of barometric pressure. In the seventh grade a course of physical science is planned to give training in manipulation and careful measurement and power to reason from simple numerical relations. The work in this grade should aid in accuracy in manual training and number work. In the eighth year, principles of diffusion, solution, and chemical change are applied in physiology.

Weather Records.—In the lower grades it has been found that a continuous weather record, no matter how ingenious the devices for keeping it, after a time grows monotonous to the children and ceases to have as much value as is usually ascribed to it. It is believed that there is greater value in the occasional record that is kept at times when conditions are typical. In order to do this the teacher must learn to read weather maps, and be able to forecast the probable results of conditions represented. By keeping track of the maps from day to day she will be able to know when well-marked conditions are about to present themselves, and can then take the record so as to include the time during which these occur. Such records will probably be taken once or twice during each season. The more advanced work in meteorology will be included under the course in geography.

In this course the work in minerals, soil, and erosion is done in the simplest way in the first three years of the course. For a fuller development of this side of elementary science the outline for the course of study in geography must be consulted.

III. Outline of Course in Nature Study

First Grade. Three thirty and two fifteen minute periods throughout the year :

I. Garden work in the fall *: (X, 104, 108. †)

Study of common vegetables planted in the previous spring when children were in the kindergarten.

List of vegetables: carrots, turnips, beets, radishes, potatoes, squashes, pumpkins. (XI, 113, 114, 118, 119.)

Leading points for observation:

1. Plant as a whole.
   Comparison of plant in fall with condition in the spring.
   Make simple drawings showing general appearance of foliage, whether thick or scanty, height above ground, etc.
2. Form of leaves. Do we eat leaves or stem ?
3. Kind of flower. What becomes of it when it fades ?
4. When do the various vegetables form their seed ? Collect the seed. Compare the part of the plant put into the ground in the spring with fruit in the fall.
5. Gather in all but a few of the vegetables. Compare the number of potatoes or quantity of seed which is obtained with the amount planted in the spring.
6. Storage of food in vegetables.‡ Why we use them as food. Storage of harvest for the winter. Preparation of vegetables for market.

* There will be some care of the garden during the summer months in order to check the growth of weeds.

† Numbers refer to the bibliography.

‡ If the vegetables are good, healthy ones, they should be given to somebody or made some use of, perhaps fed to rabbits, but not wasted.

II. Trees:

In the fall — the oak. (IX, 102.)

The oak is chosen because there are good specimens on the other side of the street, and because there is so much about the tree that appeals to children of this age.

1. General appearance.
2. Changes in leaves and the form of leaves.
3. Time of shedding leaves.
4. Fruit.

In the winter — the pine. (IX, 85, 94.)

1. Shape of the tree.
2. Needles. Compare with oak leaves. Odor of broken needles and stems.
3. Bark.
4. Cones. Where are the seed?

In the spring — the apple. (V, 68.)

1. Appearance of the tree.
2. Winter twigs. (Cornell Leaflet No. 3.)
3. Opening of leaf buds.
4. Opening of flower buds.

III. Fruits — especially the apple (Thanksgiving time):

Form and colors of different kinds.
Internal appearance.
Seed. Keep some to plant in the spring.
Packing for market.
Preparation of dried apples.

IV. Squirrel and rabbit: (II, 14, 17, 21.)

Squirrel.

May be observed with oak trees, as there are some fine gray squirrels in the Columbia grounds.

1. How the squirrels live.
2. Movements.
3. How nuts are eaten:
   Use of paws.
   Use of teeth, jaws, and mouth.
   Attitude while eating.
4. How nuts are gathered.
5. How nuts are stored.
6. Try to get the squirrel to take food from the hand.
7. After this out-of-door study, a squirrel may perhaps be studied for a short time in the class-room.

Rabbit:

Have one or two healthy rabbits in the class-room, and give them the best of care while they are with you.

Read parts of Thompson's *Raggy Lug* to draw attention to characteristic ways. Compare with squirrel.

1. How the rabbit eats:

Kinds of food.

Form of mouth.

Use of teeth and jaws.

Introduce here the way in which we use our teeth; why we should chew our food well, and how take care of the teeth.

2. Movements:

Use of hind limbs and fore limbs. Contrast use and general structure.

Use of feet.

Movements of the tail. Form of tail.

Movements of the ears.

3. Natural covering:

Observe also the covering of the squirrel. Does it seem thicker now than in the early fall? Compare with covering of the rabbit.

V. Effects of frost:

On life.

1. Twigs. Bring twigs into the class-room, break them; allow them to stand in water and try to break them again. Break off buds out-of-doors to see how brittle and frozen they are.
2. Vegetables in the garden.
3. Effect of frost on leaves.
4. Effect of frost on roots.

On the garden soil.

1. Examine the soil in the garden.
2. Bring a large piece into the schoolroom, and watch the results.

On water.

Forms of water — ice, snow, steam. Perform simple experiments to illustrate forms of water.

VI. Sediment in water:

1. At the time of a heavy rain collect some rain-water in

one vessel and put soil-water in another. Evaporate by boiling and notice sediment.

2. Allow water to pass through clean sand — through clay — through some of the garden soil. Use muslin or paper filter.

VII. Effect of thaw :

1. Appearance of the ground.
2. Ice in Hudson River.
3. Limberness of twigs.

VIII. Duck—Specimen arranged in the pond in the court.

1. Use of the feet in swimming and walking.
2. Form of the body. How does the form aid the animal in swimming ?
3. Use of the wings.
4. Eating. Kind of food needed. Notice the form of bill.
5. Covering.

Shedding of water by bird feathers.

IX. Garden work in the spring:

1. Plant seeds in the garden, care for them, and watch growth.

List of plants to be studied in the fall : Peas, beans, balloon vine, morning-glory, pansy, poppy, onion, asparagus.

2. Measure the amount of seed put into the ground. Make a record of the amount of each seed and where and when planted, and of weather conditions at time planted.

X. Weather records in this grade include — condition of sky, direction of wind, presence of rain, snow, fog, etc.

Second Grade. Three thirty and two fifteen minute periods throughout the year :

I. Garden work in the fall — study of plants started in the previous spring.

Refer to records made at that time and compare the appearance of plants and the conditions of weather.

Form of plants and appearance of foliage.

Flowers.

1. Falling of petals.
2. Time of fading of flowers.
3. Formation of fruit from the flower.

Dehiscence of seed.

1. How far do seed fall from parent plant?
2. Collect all the seed possible and compare the amount collected with what was planted in the spring.

II. Trees. (Any of the books under XII.)

In the spring—comparative study of elm and sweet-gum tree:

1. Sketches of their general forms.
2. Difference in the buds.
3. When do the leaf buds appear? When do flowers appear? Examine, if possible, flowers of both trees. The elm blossoms can be very easily obtained.

In the fall—the oak.

Follow same outline as given for trees study in first grade.

In the fall—the sweet gum.

Follow same outline as given for trees study in first grade.

In the winter—the spruce.

Follow same outline as given for trees study in first grade.

Tree in Columbia grounds. Same outline as for pine. Comparison with the pine.

III. Cow, sheep, and beaver. (II, 21.)

Cow:

1. Characteristics of the animal.
2. Value to man.
3. Simple study of milk.

Butter and cheese making. Value of milk as food.

Sheep:

1. Characteristics of the animal.
2. Uses to man.

Clothing of our bodies in winter. Care of the skin, etc.

3. Comparison of cow and sheep.

Beaver (in connection with *Hiawatha*):

Use the large Audubon illustrations. Examine a piece of the fur.

1. Make prominent the life, habits, and work of the beaver, the changes he is able to make in watercourses, vegetation, etc.
2. Compare important structural characteristics with squirrel and rabbit.

The cow, sheep, and beaver may also be connected with the clothing of the North American Indian in skins, woollen blankets, and fur.

IV. Rocks:

Effect of frost on rocks.

1. Examine rocks that are exposed in the neighborhood.
2. Difference in the appearance of exposed surface and freshly broken surface.

How does this rock break apart?

A few of the common rocks.

1. Mica schist, so common in the neighborhood.
2. Granite, use for paving-stones.
3. Sandstone, use in trimmings of our school building.

Some of the minerals found in them.

Of what is sandstone made up. Examine a number of different specimens.

V. Action of rain on soil in the garden:

Effect on the bank—action of water on sand.

VI. Chicken and pigeon:

To be taken separately at first and afterward comparatively. They are both scratchers and have many things in common. We have chickens and pigeons in abundance in the neighborhood, but in addition to the observation of them out-of-doors or in the barnyard it is possible to keep a pigeon or small hen in a moderately large, strong cage for a week or so without making the animal very uncomfortable. In this way these commonplace objects may be studied more carefully and very interesting facts of habit and structure gained.

Follow the line of thought suggested for the study of the duck in the first grade.

VII. Garden work in the spring:

Preparation of the ground. (XV, 152, 153.)

Ways of ploughing, hoeing, etc.

Measure quantities of each of the different grains, maize, rye, oats, wheat.

Different times for planting.

Keep record of when planted.

Conditions needed.

VIII. Germination of pea, bean, and squash:

Examine dry and soaked seed.

Examine different stages of growth, and the development of the little plant within the pea and bean. Is there a similar miniature plant in the squash?

How do the plants of these different seeds get out of the ground? (Cornell Leaflet No. 1.)

Make sketches to show this process of growth.

IX. Weather records—temperature, direction of wind, presence of rain or snow, clouds.

Third Grade. Five fifteen minute periods throughout the year:

I. Gardening in the fall:

Harvesting of grain planted in the spring. (XI, 111.)

1. Characteristic appearance of the different plants.
2. Proper time for harvesting.
   When were the grains formed?
   Reason that our crop may not be as abundant as the farmers'.
3. Amount of material secured from the crop.
   Thresh out the grain.
   Weigh each kind. Weigh the husks. Weigh the straw.

Use of straw. Strength of straw.

Plant winter wheat.

II. Study of the cornstalk.

Structure of stem.

Arrangement of leaves on the stem.

1. Sheaths at base of the leaf.
2. Strength produced by structure of leaves and stem.

Position of the ears on the stem.

What is the silk? Where does it come from?

Do the blossoms at the top of the stalk produce seed of any kind?

(This plant affords an illustration of two kinds of flowers upon the same plant.)

III. Cereals. (XI, 111, 117.)

Maize in its different preparations for market and grinding (some primitive ways) and some of our modern preparations,—indian meal, hominy, farina, samp.

Wheat and rye. Grinding into flour. Different qualities of flour.

Bread and bread-making.

1. Primitive methods.
2. American methods.

3. Experiment with wheat flour to separate starch from gluten.
4. Test for starch.

Value of cereals as food.

Digestion of food — give this very simply.

IV. Cat: (II, 21.)

(A pet cat may be brought to school for study).

Study in reference to value in home; in grain regions.

Why introduced into Europe?

Characteristic manner and habits.

Principal structural characteristics related to life and habit.

Structural features showing relationships.

1. Mouth and teeth.
2. Claws and other parts.

Use of different parts of the body.

Covering—Care of the body—Cleanliness of the animal.

V. Trees:

In the fall—maple.

Follow same general outline as suggested for other trees.

Collect other winged fruits, elm, ash, tulip, and others.

In the winter—cedar tree on Columbia green — compare with spruce and pine.

In the spring—the maple.

1. Running of sap.
2. Leaves and foliage.
3. Blossoms.
4. Germination of the seed.

VI. Horse, mule, and camel. (II, 21.)

Studied as beasts of burden in connection with transportation of food and also as living animals with characteristics of habit, structural adaptation which have made them of great value.

Take each animal separately at first as with all animal study, and afterward make comparison.

VII. Birds: (III, 33, 35, 47, 48, 49, 52, 53.)

Class-room observation.

Some of the tame brown finches may be obtained from a dealer in live animals. They are comparatively quiet, and are somewhat like our sparrows.

1. How the bird eats and drinks, use of the throat, shape of the bill.

2. How it moves about.
   Careful study of feet and toes.
   Use of the feet (characterizing these birds as perchers).
   Compare with chicken, pigeon, and duck.
3. Care of the body.
4. Sounds.

Common birds in the neighborhood — robin, starling, grackle, sparrow (English), chippy, vireó, phœbe.

Study out-of-doors and from mounted specimens and pictures.

1. Characteristics.
2. Kind of food and how obtained.
   Watch the robins on Columbia lawns.
3. Nesting habits and nests.
   Condition imposed upon the bird in selecting the site of the nest and building the nest.
   Locality (opportunity afforded for nests).
   Condition of the young at birth.
   Structure of the bird — bill, feet, body, etc.
   Feeding habits of the bird.
   Temperament, whether solitary or social.
4. Examine the structure of a few of the nests.
   Forms.
   Materials used in construction.

Fourth Grade. Two thirty minute periods throughout the year:

I. Special tree for the fall — sycamore:

Bark—this will probably be the first part of the tree noticed.

1. Compare the pieces of bark that have been shed with the covering of the trunk.
2. Why does a tree shed its bark? Do all trees shed bark?
3. Compare the trunk and trunk covering of the sycamore with the oak, maple, etc.

General form:

1. Branching.
2. Height and breadth of the tree.

Make blocked-in sketches of the elm, sycamore, birch, maple, and oak, showing characteristic form of each.

Leaf:

1. Compare the form of the leaf blade with that of the maple and sweet-gum.
2. How is the leaf fastened to the stem?
3. Where are the leaf buds for next year?
4. When do the leaves fall and what changes take place in the leaf before its fall?

Fruit:

1. How fastened to the stem?
2. Where most abundant on the tree?
3. Compare with the fruit of sweet-gum.
4. What kind of seeds are found. Compare these with the sweet-gum.

Draw and paint the tree as it looks in the late fall.

II. General appearance of the trees (V, 69. I, 89. XII, 123, 126):

Make excursions to grounds in the neighborhood where oak, maple, sweet-gum, birch, sycamore, elm, pine, and spruce may be found.

Review of prominent characteristics of trees previously studied.

Recognition of trees at different seasons.

General questions for field work (IX, 91, 93, 98, 100):

1. Difference in height of trees.
2. Difference in foliage masses.
3. Advantage of different types growing together.
4. Which trees have the greatest number of branches? At what height from the ground are the branches given off?
5. Result of crowding.
6. What can be done to make a tree grow with a tall, straight trunk?
7. What is the effect upon the wood if numerous branches are allowed to develop?
8. Why must dead branches be cut off? Why cut them close to the trunk? Why do gardeners sometimes coat the cut end of a branch with pitch?

Examine a section of pine knot; boards with knot-holes; boards with decayed spots under the bark (ix, 88).

III. Care of trees and forests (IX, 91, 93, 98, 103):

Some ways in which destruction of forest areas has come about.

1. Fires, careless cutting, etc.
2. Insect pests.

Describe some of the more common pests, and ways of destroying them.

Ways of preventing destruction.

Let some pupil write for pamphlets, and discuss the efforts that are being made to save the trees and forests. Compare our forest tracts with many forest areas in Europe.

IV. Wild life in the woods (II, 14, 17, 21. XVII, 164).

Make a list of some of the animals seen in the woods in which we have been and talk about some of their interesting ways, their enemies, and means of protection. Life in the winter. Snow tracks.

Something should be said of the rights of the wild animals, and of the greater satisfaction that comes from the study of their habits and haunts, than from the mere shooting of them to improve one's aim as a huntsman or from the wearing of their furs and feathers.

Hunting centres in the United States. See under geography.

1. Dog (II, 16, 17, 21).

In connection with hunting.

Qualities which make him of assistance:

Keen sense of smell and hearing.

Strength combined with speed.

Strength of paws for digging, of limbs and body, and of jaws and teeth.

Fidelity and obedience.

Examine important structural features and covering of the body.

In connection with domestic pursuits.

Shepherd dogs. Care of flocks and herds.

Beast of burden. Eskimo and Newfoundland dogs.

Messengers. St. Bernards.

Companions and pets. Some modes of expression.

2. Relatives of the dog (same reference as for Dog).

Wolf, fox, coyote.

Relationship shown by structure.

Excursion to the Museum of Natural History.

Relationship shown by habits.

If possible see these animals at the Zoölogical Garden.

V. Lumbering (see geography):

Lumbering regions and forest reserves (IX, 93).

Where situated throughout the United States.

Most conspicuous trees of these regions.

Lumber camps (IX, 84, 93, 100):

1. Sites chosen — reasons.
2. Why is winter a good time for cutting and hauling?
3. Transportation from the lumber camp.

There is a fine picture of a log jam in the New York State Report of the Fisheries and Game Commission for 1896.

Saw-mills:

1. Situation.
2. Management.
3. Power used for operation.
4. Ways of preparing wood.

VI. Woods (IX, 88, 96, 99, 98).

Examine the wood-work in the schoolroom.

Notice the different kinds of grain found.

What is the grain of wood? Why do pieces of wood differ so much in grain?

Examine small logs of different woods cut in cross, longitudinal, and radial sections.*

Growth of the wood (V, 66, 68):

1. Meaning of rings in the wood.

Hornbeam and sumach in cross section show the annual rings well, as the wood cells formed at the beginning of each season are very large in comparison with those formed later.

* Through the kindness of one of our large wood dealers, we have obtained a small collection of short pieces of odd logs from four to seven inches in diameter. These were cut into sections as described above and smoothed so as to show the grain, the bark being left on the outside of the log. Among the specimens obtained in this way are, oak, elm, maple, cedar, black walnut, cherry, sycamore, beech, birch, dogwood, and ironwood. It would be well if this work could be done by the children, but while this subject is well related to the manual training, the children in this grade have not skill enough to cut the sections without hurting themselves. After the main cutting is done, however, the boys can smooth the cut surfaces to show the grain and can give them a thin coating of shellac to prevent checking.

2. Green layer under the bark.
   Injury caused by girdling trees.
   Injury sometimes inflicted by horses and cattle.
3. Movement of sap in the spring — Maple-sugar making.

   Do not go far into the explanation of the movement of sap.

VII. Aquatic forms observed in connection with Kingsley's *Water Babies.* (XIV, 147, 148.)

   Jars containing dragon-fly nymphs and caddice worms may be placed in the class-room in the early spring (specimens must be collected in the fall) and left for observation at odd times. In the same have an aquarium filled with plants, fish, tadpoles, and snails (XVII, 165).

VIII. Fish, lobster (crayfish), and crab:

   In connection with fishing centres and industry. See geography.

Crayfish (I, 5).

1. Habitat.

   While describing the habitat, set up the tank aquarium before the children and arrange the materials as far as possible to resemble natural conditions. See page 49.

2. Kind of food.
   Insect larvæ and worms, tadpoles, small aquatic animals, dead animals, meat, aquatic plants.
3. Existence during winter.
4. How it eats, walks, swims, breathes, and sees.
5. Parts of the body involved in performing these different functions.

Fiddler crab.

1. Habitat.
   Arrange the tank as before, following directions given on page 50.
2. Other points of study as for crayfish.
3. Constant comparison between these forms.

Fish (I, 3. XIV, 149. [illegible] 21).

1. Habitat of different kinds of fish.
   Those that spend their lives in fresh water.
   Those that live in salt water and come up the rivers in the spring.
   Reason for spring migration.
   Return to salt water.
2. Perfect adaptation of the fish to its environment.

3. How it eats, swims, balances its body, breathes.
4. Covering of the body.

Examine the scales of a fish brought from market.

Excursion to the Aquarium in Battery Park.

IX. Trees in the spring (V, 68. XII, 123, 126. XVII, 164).

Blossoms and time of blossoming.

Special study of the tulip or whitewood tree.

This is one of the handsomest trees near New York and should be known. There are several good examples along the bank of the Hudson north of 163rd Street and in Riverside Park, but the best of all are in the Botanical Gardens in Bronx Park.

1. General form.

Its crown, trunk, and general outline—Characteristic branching.

2. Leaf and foliage.

Curious form of the leaf, beauty of texture, beauty of the mass of foliage.

3. Blossoms.
4. Twigs and buds.

Watch unfolding buds. How are the young leaves wrapped?

Position of leaf buds.

From which part of the stem do the flowers come?

Fifth Grade. Three thirty minute periods throughout the year:

I. Nut trees and nuts:

Excursion to grounds in the neighborhood where red and white oaks may be seen (XII, 123, 126. IX, 102).

General form of the tree.

Arrangement of branches.

Relation of trunk and crown.

Characteristic appearance of the foliage.

Characteristic appearance of the bark.

Leaves — form.

Acorns — notice cups, particularly the relative size of cups and nuts, and the scales on the cups.

Excursion to Fort Lee for observation of the various oaks.

Review red and white oaks and study the scarlet, black, and chestnut oaks in a similar way to that outlined above.

Learn to distinguish main characteristics of the different oaks.

General questions for field work.

1. At what distance from the parent trees are the nuts found?
2. How many seedling trees in the vicinity of the parent?
3. Under what conditions do the young trees thrive best?

Excursion may also be made to 165th Street on Hudson River.

Excursion to Fort Lee for study of hickories and beech and chestnut.

Study characteristics of each of these trees as for the oaks.

Review other nut trees and make comparison along the following points:

General form.
Foliage mass.
Height of trees.
Form, covering, and length of trunk.
Compare trees grown in the open and those in crowded areas.
Forms of leaves.
Structure of the nut and outer nut covering or husk.

Make collections of nuts (XI, 112. V, 68, p. 280).

Kind of tree or plant from which they come.
Where and how cultivated.
How brought to market.
Commercial value.

Germination of acorn, beech, and chestnut (V, 68).

This may be done in fall or spring.
Find the germ in other nuts beside those mentioned.

II. Heat (XVI, 156, 158, 159):

How produced.

1. By friction.

Ex. 1.

Fasten a strip of tin to a block of wood and grind the tin upon a grindstone until it is hot enough to light a small piece of phosphorus upon a plate.

Hot axle on cars; on wagons. Machinery warms up while running. What is done to obviate this? Saw gets hot while sawing wood. Grease used to reduce friction and thereby diminish heat. The charring of a stick of wood by rubbing it against a rapidly moving wheel.

Ex. 2.

Produce spark by striking a pebble a glancing blow against a rasp.

Sparks produced by emery wheel. Horse's shoe striking the pavement. Scissors grinder. Car brakes.

Ex. 3.

Try to light a *friction* match by drawing it across, first, a very smooth surface (a pane of window glass) and, second, a rather rough surface (a pane of ground glass). Why does it light more easily upon one surface than the other?

2. By chemical action.

Ex. 4.

Hold in the palm of one hand a small dish containing a piece of quicklime as large as a hen's egg. Add cold water and note the heat which will be produced. Give plenty of time and note how the heat increases. Use the thermometer and see if the temperature rises as high as the boiling-point of water (100° C.).

Slow decomposition of organic matter: pile of green grass; grain elevator; cotton baled with the seed left in; piles of oily cotton waste; hay put into a barn before it is properly cured; animal heat.

Some effects of heat.

The following experiments are given to lead to the realization of heat as a force.

1. Expansion of gases.

Ex. 5.

Heat a flask having a piece of rubber tissue tied air-tight over its mouth. Notice that when the flask is heated the rubber tissue bulges outward.

Ex. 6.

Hold the bulb of the air thermometer in the palm of the hand for a short time and note the height of the liquid in the tube. Rub the palms of the hands vigorously and close them around the thermometer bulb. The tube goes through the top of a closed vessel, and dips into some colored liquid. Why does the liquid rise in the tube when the temperature falls, and fall when the temperature rises?

2. Expansion of liquids.

Ex. 7.

Fill a test tube about one third full of water. Plug the tube by inserting a tight-fitting rubber stopper half-way into it. Heat the water in the test tube until the rubber stopper is forced out.

Steam-engines.

Ex. 8.

Repeat Ex. 5 with a mercury thermometer. Find what is the temperature of your blood, by placing the bulb of the thermometer under the tongue. Do the same with the temperature of the air in the room, the water from the faucet, or other specimens of water which may be furnished you.

Ex. 9.

Note the size of bore of the tube of a broken thermometer. What is the advantage of having the tube so small and the bulb so large? What advantage in thin walls for the bulb?

Ex. 10.

Contraction by cold is in the following case more than balanced by expansion of crystallization.

Fill a one-ounce narrow-mouth bottle with water, cork it, and surround it with a mixture of ice and salt in a tumbler. In fifteen or twenty minutes the water should have frozen and broken the small bottle.

Why does ice float upon water?

3. Expansion of solids.

Ex. 11.

Illustrate the expansion of solids by heating a wire. The wire is stretched tightly and then heated.

Setting wagon tires. Cracking lamp chimneys. Allowance made for expansion by heat in the case of iron bridges, etc.

Ex. 12.

Unequal expansion of different metals. Apparatus made of pieces of sheet tin and sheet copper riveted together and heated in a flame.

How diffused.

1. By conduction.

Ex. 13.

Heat at their conjunction an iron and a copper wire which have been linked together. Pass the hand along each wire toward the flame to determine which is the better conductor of heat. Burn a match at one end; why is there no heat perceptible at the other end? Melt a short piece of glass at one end while holding the other end in the hand.

Ex. 14.

Heat two iron wires in the flame—one a very thin wire and the other a thick one. Why does the small wire quickly reach the melting-point of iron while the larger one is scarcely heated red hot?

Ex. 15.

Hold in a flame a piece of thin wire gauze made of the same wire as above, with meshes about 40 to the inch. Why is it not easily heated red hot? Why does not the flame pass up through the gauze? By means of a lighted match determine whether unburned gas is passing up through the gauze.

Ex. 16.

Extinguish the flame of the Bunsen burner, lay the wire gauze over the mouth of the lamp, turn on the gas and light it above the gauze, and slowly raise the latter. Why does not the flame extend through the gauze to the mouth of the lamp?

Ex. 17.

Use the apparatus illustrating the miners' safety lamp. Light the lamp and pass it into a bottle of illuminating-gas. Try to bring an unprotected flame to the mouth of the bottle.

This experiment is taken in connection with the study of mining in the geography of this grade.

Ex. 18.

Float an evaporating dish upon a vessel containing a small amount of water (a beaker is convenient). Immerse a small thermometer bulb upward in the water. Pour alcohol into the evaporating dish and light it. Notice that the water boils where it comes in contact with the sides of the dish. How is the thermometer affected? Try the same experiment with the thermometer bulb downward. In each case after taking the thermometer reading, stir the water and read again. Is water a good or poor conductor of heat? Does the summer's sun heat bodies of water to any great depth?

2. By convection.

Ex. 19.

Cause a current of air to pass through a pasteboard box by means of two Argand-lamp chimneys and a lighted candle. To detect the course of the current bring a smoking lamplighter to the top of the chimney in which the candle is burning. Then bring it over the other chimney and explain why smoke goes down that chimney and up the other.

Evaporation — an effect of heat.

1. Aid of heat in evaporation.

Ex. 20.

Warm a plate and put it by the side of a cold plate. Put a drop of water upon each and note the time of evaporation in both cases.

Dishes taken from hot rinsing-water dry quickly; not so if the water is cold. Clothes dry more rapidly when wrung out of hot water than cold water; when hung near a hot stove than in a cold room. The body dries faster when coming from a hot bath than from a cold one.

2. Aid of currents of air in evaporation.

Ex. 21.

Evaporate drops of water from two plates. Blow across one of them.

Clothes dry more quickly upon windy than upon still days. "Muggy days." Humidity.

3. Some substances may pass directly from the solid to the gaseous state without passing through the liquid state.

Ex. 22.

Make a solution of salt in water (about half a teaspoonful in an ounce of water) and distil a portion of it. Taste the solution and the distillate. Did the distillate pass through an invisible state in the process of distillation?

The process of distillation is illustrated by what goes on in the laundry. The water evaporates from the boiler and is condensed to drops upon the window pane. This process goes on in a large way in nature. Fog, mist, clouds, rain, and dew.

4. Distillation and condensation.

Ex. 23.

Heat iodine in a test-tube.

The evaporation of camphor. The evaporation of ice on cold, *windy* days. Clothes "freezing dry."

Ex. 24.

In a bright metal cup put water and add slowly little pieces of ice. Stir with a thermometer and notice the temperature of the water at the moment dew begins to appear upon the outside of the cup. Slowly add water, stir continually and notice the temperature of the water at the moment the dew disappears.

Drops of water upon an ice pitcher. "Seeing the breath" in a cold atmosphere. Frost on the window pane. The evaporation from ocean, and lakes which have no outlets, must be equal to all the water which is supplied to them by rivers and rain.

III. Clams and oysters (I, 7, 8. II, 11).

Material.

1. Fresh-water clams in an aquarium.
2. Salt-water clam Mya for special study. Salt-water clam Venus (common hard-shelled clam), for comparison.

Outline of study.

1. Habitat.
2. Movement of the foot.
3. Action of the syphon.
4. Examination of internal and external aspect of shells of clams and oysters. Significance of the markings.

IV. Snails and slugs (same references as for clams and oysters):

Material.

1. German land snail.
2. Ordinary garden slug.

Outline of study.

1. Habitat.
2. Food — damage to gardens.
3. Eating. This is one of the most interesting processes connected with the life of the snail. Let the children discover how it is done.

   Where does the German snail get the lime with which it makes the air-tight cover at the opening of its shell?
4. Locomotion.
5. Sensitiveness.
6. Comparison between snails and slugs.
7. Comparison between these forms and clams.

V. Twig study (V, 66, 67, 68):

If there is time, twigs of horse-chestnut, hickory, and beech may be studied.

Prominence of certain buds and smallness of others.

Development of buds on different parts of the twig.

Size, shape, color of buds.

Shape and characteristics of bud scales.

Scars on the twig.

(1) Leaf scars; (2) bud scars; (3) flower scars.

Annual growth as shown by external markings. Compare growths of different years.

Growth and development of branches.

Position of branches.

Amount of growth in one year.

Sixth Grade. Two thirty minute periods throughout the year:

I. Common weeds (X, 106, 107. XVII, 164. V, 68):

Field work on general conditions of growth.

Take a patch of ground in a vacant lot where growth is abundant. Count the numbers of different plants found. Which seem to have gained the strongest hold? Look for peculiarities which have enabled some of these plants to increase.

Examine a neglected spot along the margin of a market garden. Do you find any new kinds of plants that were not found in the other patch?

1. What is a weed?
2. Conditions under which they thrive.
3. Damage to agriculture.
   - Effect upon the soil.
     - Exhaustion of water.

       Notice the great, coarse, succulent leaves of some weeds, and how quickly these give off moisture and fade. After the stems of such faded leaves are placed in water, notice how quickly it is sucked up by them.

     - Exhaustion of food materials from the soil.
   - Crowding of other plants.
4. How to get rid of weeds.

Special study of some common weeds.

The following weeds are common in the vicinity of New York city, and are valuable for detailed study. If this work is begun in the latter part of September or early part of October, many of the plants will be still in bloom. It will be well, however, to gather flowers and fruits, and preserve them in 5% formalin, so that the flowers may be referred to when the fruit is studied. Seed-vessels of nearly all the weeds remain on the plants during the winter, and the seeds are scattered gradually.

1. Stramonium.*

   This plant may be found in latter part of September with flowers and fruits in all stages.

   - Plant as a whole—general form, arrangement of stems and leaves, leaf surface exposed to sunlight.
   - Localities in which it is found.
   - Means of protection against enemies.
   - Principal organs of the flower.
     - Which part of the flower develops into the fruit? Make a series of drawings to show the changes undergone by the pistil.
   - Formation of the seed.

* After examining these plants the hands should be thoroughly washed.

Is there anything within the ovary which corresponds to the seed in the ripened pod?

Open the ovary of a pistil with a penknife. How are the ovules nourished? How are they ripened?

Introduce here the simplest facts concerning pollination.

Do any insects visit the flowers? Is there anything about the flowers to attract them? If possible, watch an insect make its entrance and exit from the flower.

After pollination what becomes of the corolla?

2. Burdock.

General appearance.

Localities in which it is found.

Biennial growth.

There are many whorls of large leaves that will be found living through the winter. Compare these with plants that have produced flowers and fruits. Mark one or two whorls and watch growth from them in the spring.

This is a good example of biennial growth.

Method of destroying this weed.

Structures which make up the bur.

Find a single flower. It will be seen that the flowers are placed within a covering that is armed with hooks.

Examine these hooks. What enables them to gain such firm hold of clothing or hair?

Find a mature seed in a dried bur. Compare it with the flower. What part of the flower is it?

Dissemination. Compare with stramonium.

In one case the seed-vessel does not open, but comes as a whole from the plant. In the other, the seed-pod remains on the plant and must open in order to scatter the seed. Do the spines on the fruit of the stramonium serve as a means of attachment to passing objects?

How far are the seeds of stramonium scattered from the parent plant?

3. Cocklebur.
   - Comparison of the bur with that of the burdock.
     - Means for dissemination.
       - Make drawings to illustrate differences.
     - Number of seeds to a bur.
       - Compare a flower.
       - Are the flowers on the plant all of the same form ?
     - Does the cocklebur last over the winter ?
4. Thistle, dandelion, and milkweed.
   - Find the individual flowers.
   - What is the use of the silk that is so abundant in the thistle ?
     - What part of the dandelion head is the downy pappus ? What purpose does it serve ?
   - Is the thistle better protected than the dandelion ?
   - Is there any characteristic of the dandelion that affords it protection ?
   - Compare the dissemination of seeds in thistles and dandelions with those in milkweed.
   - How many pods are found clustered together ?
     - Compare the number of pods with the number of flowers in a cluster.
     - What part of the flower is the pod ?
   - How do the seeds receive nourishment ?
5. Mullein.
   - General appearance.
     - Cluster of leaves at base of plant.
     - Tall stalk terminated by a spike of flowers.
       - Notice the peculiar wings along the stem, formed by the bases of the leaves.
     - Difference between leaves at base of the plant and those on the stem.
     - Is the plant a biennial or an annual ?
   - Fruit and flower.
     - (The flowers will probably be gone by the time this is studied.)
     - Form of seed-pods.
     - Means of seed dissemination.
     - Estimate number of seeds in a pod.

6. Butter-and-eggs.

Outline of study similar to that given for mullein.

Many questions concerning weeds may be left, to be answered in spring and early summer.

II. Air—properties and pressure:

1. An agent of combustion (XVI, 158).

Ex. 1.

Invert a bottle over a candle flame. Let the flame struggle until it goes out.

Ex. 2.

Perform the same experiment, but as the flame is about to go out, allow a fresh supply of air to enter the bottle.

Ex. 3.

Place a chimney over a flame so as to leave a space for air to enter from below. Place a piece of paper over the top of the chimney. When the flame is about to go out lift the paper.

Ex. 4.

Place a chimney over a flame so that air can enter only from the top.

Ex. 5.

Place a chimney over a flame so that air can enter from above and below.

Why do we close the "draught" when we wish to check a fire? Why blow a fire to make it burn?

Why do laboratory lamps have holes at the bottom?

Why do we have dampers in stove-pipes?

Ex. 6.

Thrust a lighted splinter into some alcohol. The flame is extinguished and the alcohol burns quietly at the surface. Put out the alcohol flame by placing paper over it.

Ex. 7.

Put a little kerosene into a tumbler and thrust a lighted match down into it. The match flame is extinguished.

Application to simple ways of putting out a fire.

Why do we throw water to extinguish a fire?

2. Air occupies space to the exclusion of other things.

Ex. 1.

Take two bottles of equal size. Bottle A is filled with the air of the room, bottle B is filled with water. In the mouth of each place a rubber stopper with two holes. Into one hole of stopper A pass a glass tube or the stem of a small glass funnel.

into the second hole, a bent glass tube whose longer arm shall pass through one of the holes of stopper B. Through the other hole of stopper B pass a short bent tube. Pour a continuous stream of water into the tube or funnel of A and watch the results.

Ex. 2.

Make a funnel of paper, leaving an opening of about an eighth of an inch in diameter at the bottom. Dip the funnel into water and fit it, air-tight, into the neck of a bottle. Fill the funnel with water, and after a little has passed into the bottle, the water will cease to flow, unless an air bubble is allowed to pass out. The passage of an air bubble may be shown by pressing the side of the funnel, so as to allow a bubble to pass out through the water that has collected between the paper and glass.

Ex. 3.

Use a glass funnel that closely fits the mouth of a bottle. Why do we have to lift up the funnel from the bottle in order to fill it with water?

3. Pressure exerted by air.

Ex. 1.

Tie rubber tissue over the large end of an Argand-lamp chimney, taking care that it shall be air-tight. Fill the chimney with water, and, holding a piece of paper over the top, invert it over a dish of water.

Ex. 2.

Use an apparatus consisting of a lamp chimney closed at one end by rubber tissue and at the other by a rubber stopper with one hole, through which passes a small piece of glass tubing to which a rubber balloon is fastened. Contract and expand the space in the chimney by pushing the rubber tissue upward and drawing it downward. Explain the result.

A limited application can be made to the mechanism of respiration.

Ex. 3. Fountains by atmospheric pressure and by compressed air.

(1) The mouth of a glass bottle is fitted with a one-holed rubber stopper through which is passed a piece of glass tubing nearly closed at one end. Place the tubing through the stopper in such a way that the end with the larger opening will reach into some water in the bottom of the bottle. Condense the air in the bottle by breathing into it through the glass tube.

(2) Place the glass tubing through the stopper so that the constricted end of the tubing will pass into the bottle, which contains

no water. To the outer end of the glass tube fasten a small piece of rubber tubing. Exhaust the air from the bottle. Pinch the rubber to prevent air from entering the bottle, and place the rubber tube into a tumbler of water.

Explain the results in each of these experiments.

4. Relation of heat and air-pressure.

Ex. 1.

Heat a flask having a piece of rubber tissue tied air-tight over its mouth. Notice that when the flask is heated the rubber tissue bulges outward. Allow the flask to cool until you can bear your hand on it, then pour cold water over it. Why does the rubber tissue now curve downward into the neck of the flask?

Ex. 2.

After rolling a tumbler in hot soap suds, shake it once or twice so as to entrap some cold air within it. Then bring the tumbler, mouth downward, on a plate covered with enough water to seal the mouth of the tumbler. Why do bubbles first appear outside of the tumbler? Explain their final appearance inside.

Ex. 3. Review experiments on convection.

Geographical application.

Great heat belts.

Relation of heated areas to reduced pressure.
Inflow of air where pressure is reduced.

European countries.

Seasonal changes in areas of greatest heat and cold. Relative air-pressure.

Land and sea breeze. (Without taking up the question of specific heat, the relative amounts heat of land and water may be mentioned.)

5. Barometric pressure.

Explain the way in which a barometer is made.

Meaning of low and high barometric pressure.

Why are slight differences in air-pressure so easily recorded by the barometer?

Give practice in making careful readings and measurements.

Keep record of barometric readings.

III. Distribution of Mammals (II, 10, 13, 18, 21):

Important conditions affecting life and distribution.

1. Food supply.

2. Water supply.
3. Climatic variation.

Great areas of distribution.

1. Eurasia—including Europe and temperate Asia and northern Africa as far south as the Atlas Mountains.
2. North America as far south as Mexico.
3. Africa, south of the Atlas Mountains, with Arabia.
4. India, southern China, and southern Asiatic islands.
5. Australia and the islands connected with that continent. (II, 20.)

Types distributed over great areas (same references as for distribution of mammals).

How animals are fitted for the conditions under which they live.

Excursions to the Museum of Natural History and to the Zoölogical Gardens.

IV. Pollination of some of the spring flowers (V, 66, 68, 70):

Willow and alder catkins.

Pine trees — meaning of clouds of yellow powder.

Skunk cabbage.

Some of the weeds studied in the fall should also be noticed at this time.

Seventh Grade. Two thirty minute periods throughout the year:

I. Plant societies locally associated (see V, 66, 69, 70. VII, 79. VIII, 82, 83):

Localities for field work.

1. Fort Lee, taking a section of plant growth from the water's edge over the top of the Palisades.
2. Section from the Palisades to the Hackensack meadows.
3. Caryl, New York.
4. Van Cortlandt Park.

Ecological conditions.

1. Water.

Variability in the amount needed by different plants.

Distribution throughout the year.

Water received directly from rain and snow.

Water received from underground sources.

2. Soil (XV, 152, 153, 154, 155).
   Chemical constituents.
      In a general way the kind of substance given to the plant by the soil.
   Physical properties.
      Receptivity to moisture.
      Power to retain water.
      Depth to which water can sink depends upon:
         Texture of the soil.
            Uncrumbled — rocks.
            Sand — small retentive capacity.
            Clay — great retentive capacity.
            Humus.
            Salt soil.
   Soil covers.
      Snow, fallen leaves, foliage of living plants.
3. Light.
   Varying heights attained by plants according to their need of light, and the strata of plant growth within a wooded area: forest trees, shrubs, tall herbs, low herbs, mosses, and lichens.
4. Wind.
   Exposed and sheltered situations.
      Result in richness or scarcity of foliage or in development of branches.
5. Heat. Effects of seasonal changes.

II. Distribution of plants over the earth's surface:
Important ecological conditions.

1. Heat.
   Limits of temperature between which plants can live and grow.
   Length of season in different regions.
2. Water.
   Variability in amount from complete submergence to perpetual drought.
3. Soil and light — same as for local plant societies.
4. Wind.
   Effect of prevailing winds over large areas.
      Drying winds.
      Moisture-laden winds.

Effect of wide exposure to winds.

Mountain-tops compared with valleys in vegetation.

Areas of distribution.

1. Climatic belts.
2. Altitude belts.
3. Distinctive areas of the different continental masses.

Use outline maps of the world and of the different continents.

Characteristics which have enabled plants to meet the conditions of environment imposed upon them.

III. Physical science. Light (XVI, 160):

In the following list of topics, numbers of sections and of experiments refer to the *First Course in Science*, by Professor Woodhull.

How light spreads from a centre. Section I.

Light through small apertures. Section IV.

Shadows.

Examine shadows cast by different objects.

Observations of shadow sticks on the window-sill.

Reflection.

First experiments with plane mirrors.

All miscellaneous observations on reflection.

Refraction.

Experiments with the glass cube.

Refracting power of different substances.

How refraction enables us to see the air.

How refraction lengthens our day.

Throughout the course make as intimate connection as possible with geography and number work, and aim for accuracy in the use of apparatus.

IV. Animal study — Frog and toad (II, 22, 23. I, 7):

Both may be placed in the same tank as described in the last chapter. Natural environment should be imitated as closely as possible.

When lessons are being conducted it is better to have the animals in vessels distributed to the pupils, so that the observations are as nearly individual as possible.

Habitat.

Kind of food.

Mode of catching and eating food.

Breathing.

Make comparison of the main structural features of the frog and toad.

Compare the development of frog's and toad's eggs.

Make drawings to illustrate the principal stages in the development of the frog and toad.

If possible make an excursion to secure a few eggs for study.

Eighth Grade. From February to June, one thirty-five and two forty minute periods:

General Physiology of Plants and Animals

I. Absorption of food in plants (V, 71):

1. Necessary food material.

Is water sufficient as food for the plant?

Ex. 1.

Select two pea seedlings of equal size. Place one on netting over a vessel containing rain-water, the other over soil-water. Place the two vessels under the same conditions and record growth of the seedlings.

Ex. 2.

Evaporate, by boiling, equal parts of rain-water and soil-water. Is there any substance remaining in either vessel? (It will be seen that the residue is mineral matter.)

2. Percentage of water and mineral substance in living plant tissue.

Ex. 3.

Weigh some fresh green leaves carefully. Put them where they can become thoroughly dry. Weigh them again. The loss in weight has been due to loss of water. Burn the dried leaves. The organic material will pass off in smoke and an ash will remain. Weigh this. Compare the weight of water lost by evaporation with weight of the mineral ash. Compare both weights with that of the fresh leaves.

The same experiment may be tried with slices of potato.

3. Sources of material in soil-water.

Review from previous grades the substances which go to make up soil and its physical properties.

4. Special organs of absorption.

Examine a radish seedling that has been raised on moist blotting-paper, and notice the root hairs. What part of the primary root do they cover? Examine a root hair under the microscope—(slides prepared by the teacher).

Ex. 4.

Take another radish seed that has been raised in fine sand or soil. Notice the way in which particles of soil cling to the root hairs. Examine some of these root hairs under a microscope. Carefully remove the root hairs from one seedling. Compare its growth with a seedling grown under similar conditions, but which has been allowed to retain the root hairs.

Application of facts learned from these experiments to transplanting of trees, shrubs, etc., and repotting of plants.

5. Preparation of the materials of the soil for absorption by root hairs.

Solution of substances in water.

Solution of substances in water and carbon dioxide.

Solution of substances by the acid action of growing roots.

Ex. 5.

Place seedlings, that have been started on blotting-paper, in a covered vessel so that the root tips rest upon moistened litmus paper. Do the growing roots produce any change on the litmus paper?

To test this change, put a little dilute hydrochloric acid on litmus paper and compare the result with that produced by root tips.

Ex. 6.

Fill a small flower-pot half full of common garden soil, and on the top of it lay an oyster- or clam-shell with the polished surface uppermost. Cover this with about three inches of clean loose sand. Place two or three beans in the sand, and after two weeks examine the shell.

6. Process by which substances in solution pass through the membranes of root hairs.

The following experiments may be used to illustrate the process of osmosis.

Ex. 7.

Tie a diffusion shell over one end of a glass tube (about .75 inch in diameter). Fill the tube with molasses, sugar syrup, copper sulphate, or saturated solution of common salt. Suspend the tube with the diffusion shell in a vessel of water.

Notice carefully the height of the liquid in the tube at the beginning of the experiment.

Change in height of the liquid. When does the height remain stationary? How many inches does it rise?

What change is there in the density of the liquid in the tube?

What change in density in the liquid outside of the tube?

Relative amounts of liquids exchanged between the tube and the vessel of water?

Ex. 8.

Put some molasses in a gold-beater's bag and tie the bag securely. Place it in a dish of water and watch the results.

7. Upward path of water.

Ex. 9.

Place into red ink the stem of some succulent green-colored plant, as jewelweed. After a time examine the path of the liquid through the stem.

Ex. 10.

Take a large leaf of rhubarb and beat the soft substance gently so as to separate it from the vessels in the stem.

Place a leaf of rhubarb in some colored liquid and notice the path of it through the stem.

8. Forces which carry water upward.

Root or bleeding pressure.

Ex. 11.

Take a good-sized plant with abundant leaf surface. Cut the stem about three inches above the ground. Attach a glass tube to the stem by means of rubber tubing. Pour a small amount of water into the tube to moisten the cut end of the stem. Mark by a cord or painted line the height of the water in the tube. Measure carefully from day to day the increase in the height of the water column.

Lifting power of evaporation from the leaves.

Ex. 12.

By means of a closely fitted cork, fasten a leafy shoot into one end of a straight tube that is to be filled with water. After filling it with water out of which the air has been expelled by boiling, place the lower end in a dish of mercury. How much mercury rises in the tube? Mercury is 13.6 heavier than water. How much taller column of water could be lifted in this way?

Ex. 13.

Try the same experiment with a twig of horse-chestnut before the leaves have opened from the buds.

9. Passage of water from the plant — transpiration.

The last two experiments also come under this heading.

Ex. 14.

Pass the petiole of a leaf through a small hole in a good-sized

piece of cardboard, covering a tumbler of water. Seal the hole with paraffin and invert a tumbler over the leaf. Notice the amount of water collected inside the glass (see V, 69).

Ex. 15.

Quantitative measurement of water given off by the plant.

Place a healthy plant, impatiens or a begonia, on one pan of a platform balance. Completely cover the flower-pot and the soil with rubber tissue or oilcloth. Put weights on the other pan so as to bring the scales into perfect equilibrium. After twenty-four hours look to see whether the scales are still balanced. Continue these observations for two or three days.

How much weight is lost by the plant after twenty-four hours? After forty-eight hours?

Vary this experiment if possible by placing it in different temperatures.

Structures in the leaf connected with transpiration.

Ex. 16.

Place a vigorous leaf into red ink. Notice the passage of liquid through the petiole to the main ribs and finally to the small veins of the leaf. Examine the soft tissue between the ribs. Peel some of the epidermis from the soft areas of the under and upper surfaces of the leaf, and examine the stomata under the microscope.

10. Can leaves absorb water? *

Ex. 17.

Float on water a withered leaf of fuchsia with the upper surface downward, and the end of the petiole in the air.

Why does sprinkling sometimes revive withered plants?

II. Substances built up by the plant:

1. Influence of sunlight.

Ex. 18.

Place some young plants, peas, beans, morning-glories, or nasturtiums, in a dark box for about four days. Is there any change in the appearance of the plants at the end of that time?

Ex. 19.†

Take some of the leaves of a plant that has been grown in darkness, and leaves of another grown in sunlight. Place them separately in hot alcohol to remove the green coloring matter (chlorophyll), and after rinsing them thoroughly in water, test for starch with iodine solution.

* This, and most of the foregoing experiments are taken from Macdougal's *Nature and Work of Plants* (see Bibliography, V, 71).

† This experiment needs careful work and may be found too difficult for this grade.

2. Tests for substances manufactured by the plant.

Ex. 20.

Tests for starch in plant substances.

Typical test: Place boiled starch solution in a test-tube, add a little weak iodine solution.

Soaked Indian corn: Cut a grain of soaked corn lengthwise so as to include half the embryo and half the food material. Place a crystal of iodine in the palm of the hand and hold the cut surface of the corn over it. Which part of the grain shows the starch reaction?

Test the following substances for starch:

White and sweet potato, peas, beans, turnip, carrot, onion, bread.

Ex. 21.

Tests for sugar in plants.

Grape sugar and Fehling's solution (typical reaction). Dissolve a small amount of the sugar in water. Add Fehling's solution and boil. What changes do you observe?

Test the following substances for sugar: Soaked grains of corn, sweet corn, beet, banana, grapes, apple, onion, carrot.

Emphasize the fact that plants manufacture the organic substances used by animals.

III. Gases given and received by plants.

1. Plants growing in sunlight.

Ex. 22.

Place some healthy water plants in a vessel of water into which CO_2 has been mixed. Invert a glass funnel over these plants and place a test-tube over the end of the funnel. Place the whole in sunlight, and, with a lighted spark, test the gas which may form in the test-tube.

2. Do plants give off any gas but oxygen?

Ex. 23.

Take three fruit jars. Fill one half-full of soaked peas, another half-full of dried peas, leave the third empty. Test the gas in each jar with a lighted taper. Cover the jars well, and at the end of twenty-four hours, test the gas in the jars again with a lighted taper.

3. Is oxygen needed by plants?

Ex. 24.*

In one U tube put sprouted oats and place the open end of the tube in water. In another U tube put sprouted oats and place

* W. F. Ganong, *Some Appliances for the Elementary Study of Plant Physiology.*

the open end in a cylinder containing pyrogallic acid. Watch the pyrogallic acid in the U tube. When it has risen as far as it will go, measure its height in the tube. What do you observe in regard to the oats in this U tube? Compare the result with those observed in the U tube placed in water.

It will be seen that about $\frac{1}{5}$ of the volume of air has been exhausted in the tube with pyrogallic acid.

IV. Formation and waste of animal tissues:

Kind of food needed.

1. Inorganic.

Water.

Ways in which it is taken into the body.

In solid food.

In free state.

Function in the body.

Percentage of water in muscle.

Ex. 25.

Take a piece of lean meat and weigh it carefully. Place it where it can dry thoroughly without cooking and weigh it again. What percentage, if less in weight, has it undergone?

Mineral substances.

Taken into the body directly — salt (NaCl).

Taken into the body in combination with other food (recall the amount of mineral matter in plants).

2. Organic.

Vegetable.

Plants the ultimate source of all organic food.

Animal — meat, gelatine, eggs, fat, etc.

Preparation of food for use in the body.

1. Brief account of the organs of the digestive system.

The alimentary canal essentially a tube extending through the body and specialized in certain regions to serve in the different steps of the process of food absorption.

2. Necessity of SOLUTION of foods.

Substances soluble in water. Example: salt, sugar.

Substances soluble in digestive fluids.

The following are sufficient as examples of solution and chemical changes which take place in the digestive system.

Ex. 26.

Test some boiled starch with Fehling's solution. Take some of the starch and add saliva to it. Shake the mixture and warm it gently for a few minutes. After this, test the solution with Fehling's. What change has taken place?

Ex. 27.

Place some finely chopped hard-boiled egg into a test-tube. Half fill it with water and add pepsin and a little HCl. What is the result?

Simultaneous waste and repair.

1. Evidence of waste.
   Rubbing off of skin.
   Perspiration and materials passed off with it.
   Changes in expired air.
   Ex. 28.

   Test the change in the air from the lungs, by breathing through a glass tube into a tumbler of lime-water. Test the air in the room by placing several dishes of lime-water at different places in the room.

   (Organic substances breathed out give the unpleasant odor to a close room.)

   Loss from the kidneys.
   Loss from the intestine.
2. Cause of waste. An analogy between the body and the steam-engine may here be employed: fuel and air (oxygen) taken in; changes take place; energy and heat the result.
3. Evidence of renewal.
   Growth of hair and nails.
   Healing of injuries.

V. Materials carried in the blood.
   The means by which food reaches the tissues is through the medium of the blood.
   Food in solution from the intestine.
   Oxygen from the lungs.
   Carbon-dioxide from the lungs.
   Waste products from the tissues.

VI. Method of exchange between tissues and blood-vessels:
   Process of osmosis.
   Review from study of absorption in plants.

1. The region of the vascular system where this process of osmosis can take place.
2. Lymph as a medium of exchange between blood-vessels and tissues.

Ex. 29.*

Kill a frog by destroying its brain and spinal cord. Hold the frog over a plate while removing some of the skin. Notice the transparent liquid between the skin and muscles. Examine the liquid that has fallen on the plate. Notice that it clots.

VII. Necessity of continuous blood flow:

Movement of blood in the vessels.

Ex. 30.

Place a small tadpole in a glass cell so that its tail comes within the field of a microscope. Keep the body and tail moistened. Watch the flow of blood in the tail.

Ex. 31.

A similar experiment may be performed with a frog. Wrap the frog in a wet cloth to keep the skin moist and tie the animal to a cardboard or piece of glass, and stretch one foot gently by tying soft thread to each of the outer toes, and taking the thread around the glass or cardboard.

Organ by which the blood is kept in motion.

1. Locate the heart.
2. Count the heart-beats as felt in the pulse at the wrist and the temple.
3. Examine the structure of the heart.

From the butcher's get two sheep's hearts with the stumps of the vessels, or better, the vessels and part of the lung attached. Wash thoroughly to remove blood clots. Cut one heart along the line between the ventricles so as to expose the internal structure. Explain the function of each part seen. Cut the other heart into several cross-sections, showing the relative thickness of the walls of right and left ventricles.

VIII. General circulation of the blood:

Use this topic as a summary and review.

1. Control of the heart and blood-vessels by the nervous system.

* Do not try this experiment unless it can be done skillfully.

Treat this subject very briefly and give only the simplest facts.

2. Respiration and its relation to circulation.

Martin's *Human Body*, Advanced Course, is the best general text-book of human physiology; but the Briefer Course may also serve as a reference.

IV. Sources and Care of Materials for Nature Study

One of the most serious difficulties in the way of successfully carrying out a plan of nature study, is the necessity of giving a great amount of time and energy to the securing of suitable and sufficient material for class-room work. Much time is often consumed merely in finding out where certain materials may be obtained, and in experimenting to ascertain the best means of caring for them. In the following pages some practical suggestions are given in regard to specimens mentioned in this outline.

If the needs of the winter are kept in mind, much interesting material, such as deserted bird nests, insect nests, seed-pods, etc., may be collected in the late summer. At this time, also, it may be possible to bring from a weedy lake a quantity of water-plants that will supply the aquarium for the following winter. Among the weeds that are most easily kept are, the common hornwort (*Ceratophyllum*), water milfoil (*Myriophyllum*), mermaid weed (*Proserpinaca,*) and *Cabomba.* All of these grow from the terminal bud, and should be rooted in sand or gravel. Small snails can also be brought from localities in which the weeds are gathered, and are invaluable as scavengers in an aquarium.

The school garden will furnish most of the material for plant study in the first three grades and the markets and market gardens can usually supply what the school garden does not. Reliable seed for garden planting may be obtained from any of the large dealers in seed and bulbs. If excursions are taken as suggested in the outline, nearly all specimens of twigs, weeds, and flowers may be easily obtained. Collecting at the time of the regular field excursion is valuable because objects have more significance when brought back for more special observation after the field lesson. They are not then studied in an isolated way, without a knowledge of the whole plant from which they were obtained. Moreover, collecting with the children gives an opportunity to show them how such work can best be done. Twigs, for ex-

ample, should be cut with a sharp knife, and not torn so that the tree or shrub is badly broken. If flowers are collected, only those that are to be used should be taken. It is an unpleasant sight to go into the woods near New York and find alder-bushes, willow and dogwood trees, shamefully broken and nearly all the early spring flowers picked, dug up, or trampled upon.

Good markets, such as Washington and Fulton in New York city, can furnish a variety of living specimens, among which are crayfish, frogs, thin-shelled clams, salt-water crabs, small silver- and goldfish, and turtles. Crayfish and frogs cannot be obtained at all in the winter and must be secured between April and November. Living thin-shelled clams are also more easily purchased at these times. When the living crayfish is studied, it may be well to have a small salt-water lobster or crab for structural comparisons, but specimens of either cannot be kept alive in good condition for the observation of habits. It is better to take an excursion to see these animals at the Aquarium, where they are in normal, healthy condition.

The fiddler-crab has been found of great value for individual study and for general observation at odd times during the day. These crabs are abundant on salt marshes along the Atlantic coast. This year we had fifty of them sent to us at small cost by a Long Island clam dealer.

The German garden snail that can be obtained from dealers in table delicacies is especially valuable for study and may be put aside in a dry place without further attention, until needed. Slugs may be found under decayed pieces of wood, stones, or dead leaves, both in vegetable gardens and in the woods.

Frogs' and toads' eggs, which can easily be distinguished,* may be collected in the spring from almost any shallow, muddy pond. In order to secure these, as well as tadpoles and adult frogs, a long-handled, fine-meshed net will be needed. If possible, the eggs should be taken from the water on the dead twigs or vegetation upon which they have been deposited, and should be placed in a vessel of water containing floating plants and other pond vegetation. The water should be kept fresh, and there should be sufficient of it to support the small tadpoles that hatch from the egg. It is common to see a large bunch of frogs' eggs

* See Cornell Nature Study Leaflets, *The Life History of the Toad*, by Professor Gage.

put into a small vessel of water, and in a few days after hatching numbers of the tadpoles may be found dead in the bottom of the dish.

One of the ideal conditions for keeping crayfish, frogs, etc., is to have a constant supply of fresh running water; but as there are few places where this is possible, the water must be siphoned from the aquarium or tank. A convenient siphon can be made by bending a piece of glass tubing into a U curve so that the shorter arm will reach the bottom of the tank. The siphon action may be started by pouring water into the tube in such a way as to drive all the air out of it. A finger may then be placed over one end of the tube and the end of the short arm placed in the water in the tank. The water will then drain off into the pail arranged to receive it. A piece of rubber tubing may also be used and is often preferred.

A convenient tank for keeping crayfish, frogs, toads, snails, and slugs can be made about eighteen inches long, sixteen inches wide, and eight inches deep, with handles at each end for lifting, and a coarse wire covering which will prevent animals from escaping. Although galvanized iron is somewhat more expensive than tin, it is much better, as it need not be painted on the inner surface to prevent rusting. Water that is allowed to stand for any length of time in contact with paint will dissolve sufficient of the paint to be injurious to the animals.

If crayfish are to be kept, coarse sand or gravel should be unevenly distributed over the bottom of the tank so that there shall be shallows and hollows from four to five inches deep, after the water has been poured into the tank. Flat stones should also be placed in the tank and water-plants firmly anchored in the sand or under the stones. When the sediment has thoroughly settled, put four or five good-sized crayfish into the tank. If meat or angle-worms are used as food, great care must be taken that no particles of uneaten material be left to decay.

Much the same arrangement will be suited to frogs, but a portion of the sandy bottom must be left uncovered by the water, to form a resting-place for the frogs, and a place where food, angle-worms or meal-worms, may be placed. Frogs will not seize anything that does not move, and worms that are dropped into the water are in danger of being wasted. A small clump of floating plants will be found an interesting addition.

Toads, snails, or slugs may be kept by putting about three inches of moist garden soil over the bottom of the tank, and adding moss, dead leaves, moist dead wood, small, low plants, and stones. Try, if possible, to imitate a portion of ground in the woods. When toads are thus kept in the tank it is well to sink a small flat vessel of water into the soil, so that the surface of the water is even with that of the soil. Snails and slugs may be fed upon pieces of crisp lettuce, spinach, and cabbage.

For fiddler-crabs, sand should be arranged with considerable depth at one end, gradually sloping down to the other end of the tank. Salt water, made with sea salt in portions of from twenty-five to fifty parts of the salt to one thousand parts water, should be poured into the tank so as to form a small salt-water pool at one end, leaving a bank or beach of sand at the other. If holes are made in the bank, the fiddlers will go into them and burrow still farther. For food, small salt-water clams may be opened and left near the edge of the water. In order to keep the crabs in good condition the water should be changed each day, and any crystallized salt removed from the sides of the tank.

Domestic animals or pets in the class-room give the greatest trouble and inconvenience unless there are good facilities for their care, for if neglected they are worse than useless. It is in every way better that such animals should be in the class-room only during the time that lessons are being given about them. Arrangements to hire animals for a short time can be made with a farmer or market-gardener if there are such in the neighborhood, or with some reliable city dealer in pet animals. If the animals are returned in perfect condition, the cost will not be great. While they are kept, they should be given quarters somewhat in proportion to their size, proper food, and plenty of clean building sand in which they can roll and scratch.

A good cage not larger than three feet long, two and one half feet wide, and about twenty-eight inches high, can be made of heavy guard wire with a door and movable tray. Anything made of wood is sure to be troublesome unless it can be kept out-of-doors. However, as the cage is only for temporary occupancy, it may be made of a packing-box about the size mentioned above, with top and front removed and strong wire netting stretched over the openings thus left. The edges of the netting of the top and front of the cage may be bound together with wire. The

front netting should not reach quite to the bottom of the box, but enough space should be left so that a galvanized-iron tray about two inches deep may be moved freely in and out of the cage. A good-sized opening should be made near the floor in one side of the box and a door fitted into this space. A coat of paint for the wood will add greatly to the general appearance.

Of course, no cage is needed for such animals as pet dogs or cats, which may usually be obtained from the children themselves. Even rabbits may sometimes be allowed to run about the room for a little while during the day.

Ordinary building sand may be had from any dealer in building materials at about twenty-five cents a barrel, if the barrel is furnished, and hay, which is often needed for food or bedding, may be obtained at small cost from feed stores, or sometimes from market gardens, but there is usually a charge for the delivery of so small a quantity.

It is fully realized that there are schools in which it would be impossible, from lack of space or suitable equipment, to carry out some of the arrangements suggested. It is believed, however, that all the material for plant study, nearly all the animals, except the pets, and all the physical apparatus, except, perhaps, that used for the experiments in light, can be obtained at very small cost. All physical apparatus, as well as one galvanized-iron tank, and two or three glass aquaria, can be made part of the permanent equipment of the school.

COURSE OF NATURE STUDY IN THE ELEMENTARY SCHOOL

Seasonal Arrangement of Subjects

GRADE	AUTUMN	WINTER	SPRING
1	Garden work Tree—oak Fruits, especially the apple Squirrel Weather record	Rabbit Tree—pine Effects of frost Forms of water	Condition of the ground and sediment in water Trees—apple and oak Duck Garden work
2	Garden work Trees—sweet-gum and elm Cow Weather record, cloud forms	Tree—spruce Sheep and beaver Rocks in the neighborhood Cloud forms, weather	Trees—sweet-gum and elm Chicken and pigeon Action of water on soil in the garden Germination of pea, bean, and squash Garden work
3	Garden work Corn-stalk (special study) Tree—maple Cat	Grain products Flours Cereals Bread and bread-making Simplest facts of digestion Tree—cedar Horse, mule, camel	Soil Birds Tree—maple Germination Corn and maple
4	Trees and forests Sycamore especially Wild life in the woods	Dog and relatives of the dog Lumbering Common woods	Trees in the spring Tulip tree especially Lobster (crayfish), crab, and fish
5	Nut trees Oak, chestnut, hickory, and beech Nuts	Heat How produced How diffused Some effects of heat	Twig study Hickory, horse-chestnut, and beech Clams and oysters Snails and slugs
6	Common weeds General field work Different species Pollination of stramonium Fruit dissemination	Air As an agent of combustion Air pressure	Distribution of animals Pollination of some of the early spring flowers
7	Plant societies Distribution of plants	Light Experiments selected from Woodhull's *First Course in Science*	Frog and toad Local plant societies
8		General physiology of	plants and animals

COURSE IN NATURE STUDY FOR THE ELEMENTARY SCHOOL

Subjects throughout the Grades

GRADE	ANIMAL LIFE	PHYSIOLOGY	PLANT LIFE	WEATHER, SOIL, ETC.—PHYSICAL SCIENCE
1	Squirrel Rabbit Duck	Food in general Chewing Teeth Care of teeth Studied in connection with animals	Garden work in fall and spring Fruits Common fall fruits for market, apple especially Trees Oak, pine, apple	Weather records at times of typical conditions in fall, winter, and spring Effects of frost Upon life " soil " water Forms of water Water Steam Ice Conditions of ground in the spring Muddy water
2	Cow Sheep In connection with clothing Beaver In connection with study of *Hiawatha* Chicken and pigeon	Care of the body in winter Warmth Care of skin " " hair " " nails	Garden work in fall and spring Trees Sweet-gum, spruce, elm Germination Pea, bean, squash	Weather record at times of typical conditions Rocks in the neighborhood Prominent minerals in the rocks Evaporation—reviewed Cloud forms, fog. Kind of day associated with particular cloud forms Action of rain on soil bank
3	Cat Characteristics Value in home and in grain-field Horse, mule, camel (Beasts of burden in transportation of food) Birds (Perchers studied from living birds in class-room) Robin, starling, grackle, and other familiar birds	Foods Bread and bread-making Corn foods Cereals Vegetables Simple ideas of how these are digested	Garden work in the fall Corn-stalk especially studied Germination Corn, wheat, and maple Raise rice and barley in class-room Trees Maple, cedar	Soils in the garden Work of rain Service of plants in binding soil Substances of which soil is composed Examine garden soil Examine soil near rock in the open field Soil covers Earthworm castings

GRADE	ANIMAL LIFE	PHYSIOLOGY	PLANT LIFE	WEATHER, SOIL, ETC.—PHYSICAL SCIENCE
4	Dog Characteristics Relatives { wolf, coyote, fox In connection with hunting centres Fish, lobster, crab In connection with fishing centres	Out-of-door life Value of exercise	Trees and forests Common trees in neighborhood 1. Appearance in different seasons 2. Growth Care of trees Woods — Ways of cutting and uses — Method of cultivating clear wood Trees—sycamore and tulip	Water power — falling or running water Grist-mill Saw-mill Steam power Water expanded into steam Simple experiments
5	Clam, oyster Snails and slugs Oyster and clam connected with study of oyster and clam industry	Animal heat Ventilation (See Heat outline)	Nut trees Oak, chestnut, hickory, beech Appearance at different seasons Distinguish prominent species of each kind of nut tree Nuts Where obtained—culture Industrial relation	Heat How produced How diffused Some effects
6	Distribution of mammals (See special outline)	Breathing In connection with study of the air	Common weeds What constitutes a weed? Ten or twelve of the common weeds in neighborhood Relation of weeds to agriculture Flower in the fall or spring Principal organs Pollination	Air An agent of combustion Physical properties
7	Frog and toad Salamander and lizard	Care of eyes and sight In connection with Light	*Plant societies* and plant distribution (See more detailed outline)	Experiments in light Adapted from Professor Woodhull's *First Course in Science*
8	General physiology of plants	and animals		

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5. Huxley, T. H. The Crayfish. Appleton. International Series.
6. Morgan, C. Lloyd. Animal Biology. London, 1889.
7. Packard, A. S. Zoölogy. (Briefer Course.) Holt & Co.

Good elementary text-book for reference.

8. Parker, T. J., and Haswell, W. A. Text-Book of Zoölogy. In two volumes. Macmillan Co. 1899.

An advanced text-book. Good as reference for facts of classification.

II. Natural History and Distribution of Animals:

9. Baker, S. W. Wild Beasts and Their Ways. London, 1890.
10. Beddard, F. E. A Text-Book of Zoögeography. Cambridge University Press, 1895.
11. Buckley, A. B. Life and Her Children. Appleton.
12. Buckley, A. B. Winners in Life's Race. Appleton.

These last two books are good for beginners. The first deals with the backboneless, and the second with the backboned animals and their relationships.

13. Heilprin, Angelo. The Geographical and Geological Distribution of Animals. Appleton. International Series.
14. Ingersoll, Ernest. Wild Neighbors. Macmillan Co. 1898.
15. Morgan, C. Lloyd. Animal Sketches. London, 1891.
16. Shaler, N. S. Domesticated Animals. Scribner. 1895.
17. Thompson, E. S. Wild Animals I Have Known. Scribner. 1898.

18. Thomson, J. R. Study of Animal Life. University Extension Manuals. 1896.

    Essays dealing with the every-day life of animals, their activities, form, and structure; and the theory of their development.

19. Wallace, A. R. Geographical Distribution.

    This is too theoretical for general use.

20. Wallace, A. R. Island Life. Macmillan Co.
21. Wood, J. G. Animate Creation.

    A natural history of animals in four large volumes. A very good work for reference.

Special Articles and Papers

22. Gage, S. H. The Life History of the Toad. Cornell Teachers Leaflets, No. 9.
23. Hodge, C. F. The Common Toad. Nature Study Leaflet. Biology Series. No. 1. Worcester, Mass.
24. Jordan, D. S. True Tales of Birds and Beasts. Pop. Sci. Monthly, vol. 54, p. 352.
25. Jordan, D. S. The Fur Seal as an Animal. Forum, vol. 23, p. 192.
26. Muir, John. Among the Animals of the Yosemite. Atlantic Monthly, vol. 82, p. 617.

III. Birds:

27. Audubon, J. J. Birds of North America. (Now out of print.)
28. Minot, H. D. Land-Birds and Game-Birds of New England. Houghton, Mifflin & Co. 1895.
29. Nuttall, Thomas. Ornithology of Eastern North America. Little, Brown & Co. 1896.
30. Ridgway, R. Manual of North American Birds. Lippincott. 1896.
31. Ridgway, R. Nomenclature of Colors. Little, Brown & Co.
32. Studer, J. H. Birds of North America. Published by the Natural Science Association of America.

Good Books for General Use

33. Chapman, F. M. Bird Life. Appleton. 1897.

34. Chapman, F. M. Handbook of Birds of Eastern North America. Appleton. 1896.

An excellent manual with a good key for field identification, but Bird Life is a better book for beginners as it deals more with habits and characteristics of birds.

35. Scott, W. E. Bird Studies. Putnam. 1898.

A large volume full of most excellent pictures illustrating nesting habits, the young and adult birds of various species.

Popular Books

36. Abbott, C. C. The Birds about Us. Lippincott. 1895.
37. Blauchan, N. Bird Neighbors. Doubleday & McClure Co. 1898.
38. Merriam, Florence A. Birds of Village and Field. Houghton, Mifflin & Co. 1898.

At the end of this book there is a very complete list of books and publications relating to the study of birds.

39. Merriam, Florence A. Birds through an Opera-Glass. Houghton, Mifflin & Co. 1891.
40. Miller, Olive T. In Nesting Time. Houghton, Mifflin & Co. 1895.
41. Miller, O. T. Bird Ways.
42. Miller, O. T. Little Brothers of the Air.
43. Parkhurst, H. E. Bird Calendar. Scribner. 1894.
44. Torrey, Bradford. The Foot-Path Way. Houghton, Mifflin & Co. 1892.
45. Torrey, Bradford. Birds in the Bush. Houghton, Mifflin & Co. 1890.

Special Papers

46. Bailey, L. H. The Birds and I. Cornell Teachers Leaflets, No. 10.
47. Barrows, W. B. The English Sparrow. Department of Agriculture—Division Biological Survey, Bull. No. 1.
48. Barrows, W. B., and Schwarz, E. A. The Common Crow of the United States. Div. Biol. Survey, Bull. No. 6.
49. Barrows, W. B. The English Sparrow. Div. Biol. Survey, Bull. No. 1.

50. Beal, F. E. L., and Lucas, F. A. Preliminary Report on the Food of Woodpeckers. Div. Biol. Survey, Bull. No. 7.
51. Beal, F. E. L., and Judd, S. D. Cuckoos and Shrikes. Div. Biol. Survey, Bull. No. 9.
52. Beal, F. E. L. Some Common Birds in Their Relation to Agriculture. Farmers Bull. No. 54.
53. Hodge, C. F. Our Common Birds. Nature Study Leaflet, No. 2.

IV. Insects:

54. Ballard, J. P. Moths and Butterflies. Putnam. 1897.
55. Comstock, J. H. Insect Life. Teachers' and Students' Edition. Appleton.

    The most valuable elementary book for the study of insects.

56. Cragin, B. S. Our Insect Friends and Foes. Putnam. 1897.

    An aid for boys and girls in collecting and preparing specimens.

57. Emerton, J. H. The Structure and Habits of Spiders. B. Whidder. Boston, 1896.

    Short account of some of the best-known spiders.

58. Holland, W. J. The Butterfly Book. Doubleday & McClure Co. 1898.

    Large book, beautifully illustrated with colored plates that greatly assist in identification.

59. Lubbock, Sir John. Ants, Bees, and Wasps. Appleton. International Series.
60. Scudder, S. H. Butterflies. Holt & Co.
61. Scudder, S. H. The Life of a Butterfly. Holt & Co.

    A story of the life of the milkweed butterfly.

62. Weed, C. M. Life Histories of American Insects. Macmillan Co. 1897.

Special Papers and Publications

63. Comstock, A. B. Some Tent-Makers. Teachers Leaflets, No. 5. Cornell Univ.
64. Comstock, A. B. Little Hermit Brother. Junior Naturalist Leaflet, No. 3. Cornell Univ.

65. Publications of the Department of Agriculture.
(Publications on economic study of insects are very numerous.)

V. Botanical Text-Books (Elementary):

66. Atkinson, G. F. Elementary Botany. Holt & Co. 1899.
One of the very best elementary books dealing with all the main divisions of botany.

67. Barnes, C. R. Plant Life. Holt & Co. 1898.

68. Bailey, L. H. Lessons with Plants. Macmillan Co. 1898.
A collection of suggestions for the study of leaves and foliage, twigs and buds, flowers, propagation of plants, habits, and types of plants. Very valuable book—good illustrations.

69. Coulter, J. M. Plant Relations. Appleton.
Describes the conditions under which plants grow, their means of adaptation to environment, etc. Good illustrations and suggestive text.

70. Coulter, J. M. Plant Structures. Appleton.
Morphological and structural side of plant life is made more prominent in this book, although the idea of function is always present. Arranged according to groups, beginning with Algæ. The last chapter is on Ecology. As well illustrated as *Plant Relations*.

71. Macdougal, D. T. The Nature and Work of Plants. Macmillan Co. 1900.
A guide to simple experimentation in plant physiology.

VI. Standard Botanical Works:

Darwin, Chas. Works published by Appleton :

72. Movement and Habits of Climbing Plants.
73. Power of Movement in Plants.
74. Different Forms of Flowers on Plants of the Same Species.
75. Insectivorous Plants.
76. Effects of Cross-Fertilization.
77. Kerner, translation by Oliver. Natural History of Plants. 4 vols. Holt & Co.
78. Lubbock, Sir John. Flowers, Fruits, and Leaves. Macmillan Co. 1894. Also published by the Humboldt Library.

VII. Essays on Plant Life and Evolution:

79. Arthur, J. C., and Macdougal, D. T. Living Plants and Their Properties. Baker and Taylor. 1898.
Discussions of the great physiological questions. A small book, very readable and valuable.

80. Bailey, L. H. Survival of the Unlike. Macmillan Co. 1897.
81. Geddes, P. Chapters in Modern Botany. University Extension Manuals. 1893.

VIII. Ecology:

See under V, 66, 69, 70.
82. Gaye, S. The Great World Farm. Macmillan Co. 1894.
83. Minnesota Botanical Studies. Bull. No. 9. Plants Along the Shore at Lake of the Woods.

IX. Forestry:

84. Bruncken, Ernest. North American Forests and Forestry. Putnam. 1900.

Deals with the relation of the forests to the national life of the American people.

85. Pinchot, G., and Graves, H. S. The White Pine. Century Co. 1896.
86. Muir, John. California. Century Co. Chapters on Trees.
87. Shaler, N. S. Aspects of Nature. Chapter on the Forests of North America.
88. Ward, H. M. Timber and Some of Its Diseases. Macmillan Co. 1889.

Special Articles and Publications

89. Bailey, L. H. How the Trees Look in Winter. Cornell Teachers Leaflets, No. 12.
90. Fernow, B. E. What is Forestry? Dept. of Agriculture —Div. of Forestry, Bull. No. 5.
91. Fernow, B. E. Forestry for Farmers. Farmers Bull. No. 67.
92. Fernow, B. E., and others. Forest Influences. Div. of Forestry, Bull. No. 7.
93. Graves, H. S. Practical Forestry in the Adirondacks. Div. of Forestry, Bull. No. 26.
94. Gould, H. P. Evergreens, and How They Shed Their Leaves. Cornell Teachers Leaflets, No. 13.
95. Hill, R. T. Forest Conditions of Porto Rico. Div. of Forestry, Bull. No. 25.
96. Mohr, C., and Roth, F. Timber Pines of the Southern States. Div. of Forestry, Bull. No. 13.

97. Mlodziandsky, A. K. Measuring the Forest Crop. Div. of Forestry, Bull. No. 20.
98. Pinchot, G. Primer of Forestry. Div. of Forestry, Bull. No. 24. (Edition exhausted.)
99. Roth, F. Timber-characteristics and Properties of Woods. Div. of Forestry, Bull. No. 10.
100. Spalding, V. M., and Fernow, B. E. The White Pine. Div. of Forestry, Bull. No. 25. (Edition exhausted.)
101. Sudworth, G. Check List of Forest Trees. Div. of Forestry, Bull. No. 17.
102. Wyman, A. P. The Leaves and Acorns of Our Common Oaks. Cornell Teachers Leaflets, No. 8.
103. Lessons of Erosion Due to Forest Destruction. Div. of Forestry. 1896.

X. Gardening:

104. Bailey, L. H. Garden Making. Macmillan Co.
105. Clapp, H. L. School Gardens. Pop. Sci. Monthly, vol. 52, p. 445.
106. Chesnut, V. K. Thirty Poisonous Plants. Department of Agriculture, Farmers Bull. No. 86.
107. Dewey, L. H. Weeds, and How to Kill Them. Farmers Bull. No. 28.
108. Greathouse, C. H. The Vegetable Garden. Farmers Bull. No. 94.
109. Putnam, B. L. Children's Gardens. Kindergarten Review, September, 1899, p. 22.
110. Smith, C. B. A German School with a Garden. Dept. Agr. Experimental Station Circ. 42.

XI. Economic Plants:

111. Sargent, F. L. Corn Plants. Houghton, Mifflin & Co. 1899.

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112. Corsa, W. P. Nut Culture in the United States. Div. of Pomology. 1896.
113. Duggar, J. F. Potato Culture. Farmers Bull. No. 35.
114. Duggar, J. F. Sweet Potato. Farmers Bull. No. 26.
115. Handy, R. B. Asparagus. Farmers Bull. No. 61.
116. Handy, R. B. Peanuts and Uses. Farmers Bull. No. 25.

117. Tracy, S. M. Corn Culture in the South. Farmers Bull. No. 81.
118. Watts, R. L. Onion Culture. Farmers Bull. No. 39.
119. Wiley, H. W. The Sugar Beet. Farmers Bull. No. 52.
120. Voorhees, E. B. Tomato Growing. Farmers Bull. No. 76.

XII. Popular Guides for Plant Identification:

121. Apgar, A. C. Trees of Northern United States. Amer. Book Co.
122. Creevy, C. G. Flowers of Field, Hill, and Swamp. Harper. 1898.
123. Matthews, S. Familiar Trees and Their Leaves. Appleton.
124. Matthews, S. Familiar Flowers of Field and Garden. Appleton.
125. Miller, E., and Whitney, M. C. Wild Flowers of the North Eastern States. Putnam. 1895.

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126. Trees of North Eastern America.
127. Shrubs of North Eastern America.
128. Vines of North Eastern America.
129. Leaf Collectors' Handbook and Herbarium.
130. Parsons, F. H. How to Know the Ferns. Scribner. 1899.

XIII. Essays on Out-of-Door Life:

Abbott, C. C. Appleton :

131. A Naturalist's Rambles about Home.
132. Days Out of Doors.
133. Outings at Odd Times.
134. Bailey, L. H. Talks Afield about Plants and the Science of Plants. Houghton, Mifflin & Co. 1894.

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135. Signs and Seasons.
136. Riverby.
137. Winter Sunshine.
138. Wake Robin.

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139. Sharp Eyes.
140. My Study Neighbors.
141. Eye Spy.
142. Highways and Byways.

143. Strolls by Starlight and Sunshine.
144. Lubbock, Sir John. Beauties of Nature. Macmillan Co. 1892.
145. Miall, L. C. Around the Year. Macmillan. 1896.
146. Van Dyke, J. C. Nature for Its Own Sake. Scribner. 1898.

XIV. Aquaria:

147. Bateman, G. C. Fresh Water Aquaria. London.
148. Rogers, M. F. Life in an Aquarium. Cornell Teachers Leaflets, No. 11.
149. Samuel, Mark. The Amateur Aquarist. Baker and Taylor

XV. Soils:

150. Briggs, L. J. The Mechanics of Soil Moisture. Department of Agriculture, Div. of Soils, Bull. No. 10.
151. Darwin, C. Formation of the Vegetable Mould. Appleton.
152. King, F. H. The Soil. Macmillan Co. Rural Series.
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154. Shaler, N. S. Soil. Article in the Twelfth Annual Report of the U. S. Geol. Survey.
155. Texture of Some Important Soil Formations. Dept. of Agriculture, Div. of Soils, Bull. No. 5.

XVI. Physical Science:

156. Tyndall, J. Heat a Mode of Motion. Appleton.
157. Tyndall, J. Forms of Water. Appleton.
158. Woodhull, J. F. Simple Experiments. Kellogg.
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XVII. Manuals of Nature Study:

161. Howe, E. G. Systematic Science Teaching. Appleton. 1894.
162. Jackman, W. S. Nature Study for Common Schools. Holt & Co. 1894.
163. Jackman, W. S. Nature Study for the Grades. Macmillan Co. 1899.
164. Lange, D. Handbook of Nature Study. Macmillan Co. 1899.
165. Wilson, Mrs. L. L. Nature Study in the Elementary School. Macmillan Co. 1899.

XVIII. Nature Study Leaflets:

Cornell University. Teachers Leaflets. Free of charge upon application.

Worcester, Mass. Nature Study Leaflets by Professor Hodge. May be obtained at cost of five cents each by applying to Professor Hodge, Clark University, Worcester, Mass.

Purdue University. Leaflets on Nature Study. Apply to Purdue University, Lafayette, Indiana.

Note on securing publications of the Department of Agriculture.—Upon application to the Department, a monthly list of publications will be forwarded, and from this list selection of papers may be made. Farmers Bulletins are furnished free, upon application to the Secretary of Agriculture. Nearly all other papers have a price affixed, and application for such must be addressed to the Superintendent of Documents, Union Building, Washington, D. C.